Interannual variability of the planktonic communities in the Northeastern Chukchi Sea

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Condensed Abstract

The planktonic communities of two nearby survey areas (Klondike and Burger) were sampled in the northeastern Chukchi Sea 3 times during the open water season in 2008 and 2009. Phytoplankton, inorganic macronutrients and zooplankton were collected at 25 stations per grid. The 2009 season saw an earlier retreat in seasonal ice cover over both survey areas than what was recorded in 2008, and thus warmer temperatures, altering the timing of the spring bloom. In total, 76 taxonomic categories of zooplankton, including 11 meroplanktonic larval categories, have been observed. The greatest taxonomic diversity was observed within the copepods (23 species), followed by the cnidarians (11 species), with all species typical for the region and largely of subarctic Pacific origin. A temporal evolution of the community structure was apparent over both areas, and it appears that cold oceanographic conditions in 2008 slowed the normal growth and development of the zooplankton, contributing to some of the inter-annual differences in community structure.

Rationale

In 2008, a multiyear, interdisciplinary study was initiated in the vicinity of two proposed oil & gas exploration areas in the northeastern Chukchi Sea. This study was designed to collect information on the ecosystem in these areas prior to exploration and to provide baseline environmental data that can be used for permit applications and for post-exploration and development comparisons.

Methods

Sampling conducted during the 2008/2009 seasons occurred within a 30 x 30 NM grid in both the Burger and Klondike survey areas (Fig. 1), at 25 stations within each study site, on three 25-day consecutive cruises. Inorganic macronutrients, phytoplankton (as chlorophyll) and zooplankton were sampled on each cruise. Phytoplankton and nutrients were collected with a CTD rosette at 6 depths per station: 0, 5, 10, 20, and 30 m, plus 3 m above the sea floor (~37 m). Smaller meso-zooplankton was collected by a pair of 150-µm mesh nets hauled vertically from within 3 m of the bottom to the surface. To target larger, more mobile zooplankton, a 505-µm mesh Bongo net was deployed in a double oblique tow with the ship underway at 2 knots.

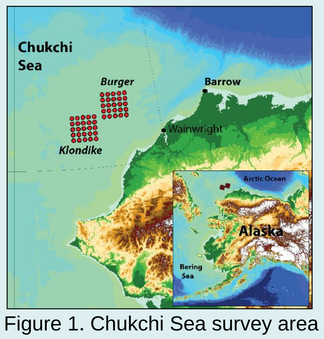

Figure 1. Chukchi Sea survey area

Physical Backdrop

The 2008 sampling season was characterized by low sea surface temperatures and late ice retreat over the sampling area (Fig. 2). Sea surface temperatures reached an average maximum of 5 °C, and northern winds allowed ice to persist over the northeastern corner of the Burger survey area. In contrast, the 2009 sampling season saw an early ice retreat and sea surface temperatures reached an average maximum of ~7 °C. These physical factors have had large effects on the structuring of the planktonic communities for the northeastern Chukchi Sea.

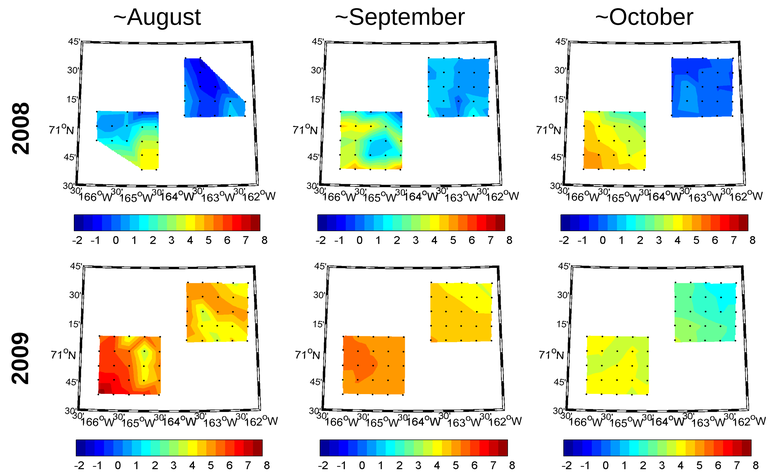

Figure 2. Average water temperature in the upper 10m during each survey.

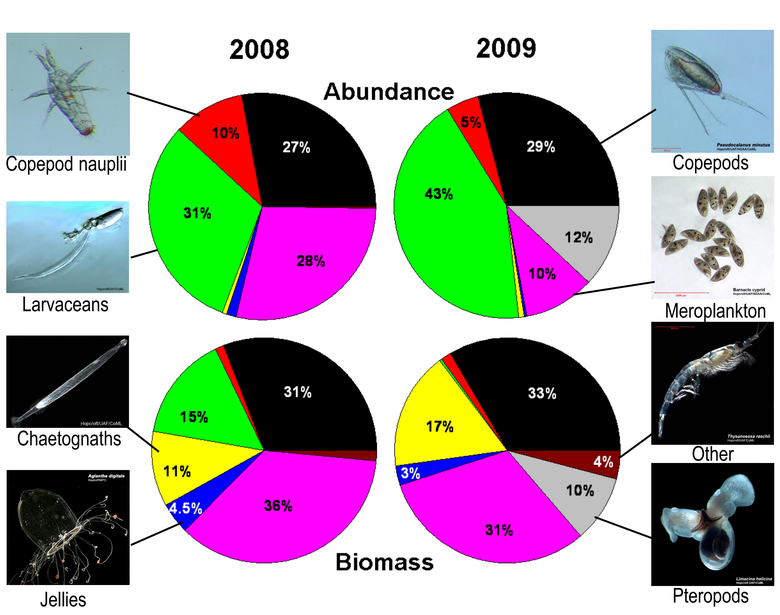

Figure 3. Averaged contribution of the major zooplankton taxonomic groups captured by the 150-µm nets in each year

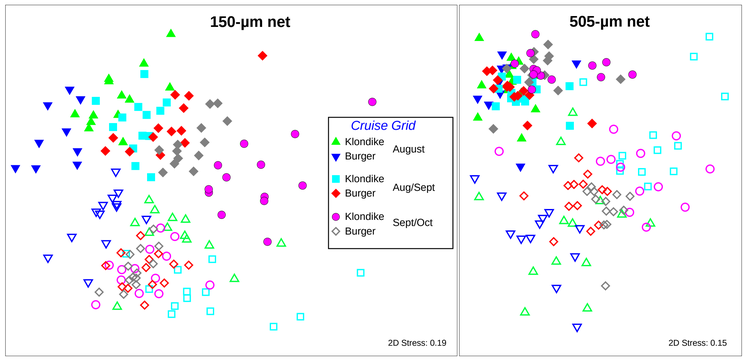

Figure 4. Multidimensional scaling of zooplankton communities for the 2008 (filled symbols) and 2009 (open symbols) field seasons.

Results

Chlorophyll & Nutrients

In 2008, integrated chlorophyll concentrations were high on the first cruise, then declined across cruises, with concentrations higher at Burger than Klondike, and a pronounced chlorophyll maximum measured at 20 to 30 m. The observed subsurface chlorophyll maxima corresponded to the depth where nutrient concentrations began to increase. **In 2009,** chlorophyll and nutrient concentrations remained consistently low through the entire sampling season at all depths for both surveys, with values similar to the end-of-season observations from 2008.

Zooplankton

We have observed 50 distinct species (within 76 taxonomic categories) of zooplankton, including 12 meroplanktonic larval categories. The majority of species are of Pacific origin, and common to both survey years. Nonetheless, the communities show both seasonal and inter-annual changes in composition.

In 2008, an average abundance of 2400 individuals m^{-3} (10.7 mg DW m^{-3}) of holoplankton and 950 individuals m^{-3} (7.8 mg DW m^{-3}) of meroplankton were captured by the 150-µm nets. An average of 106 individuals m^{-3} (8.3 mg DW m^{-3}) of holoplankton was captured by the 505-µm nets. For both sizes of nets, abundance and biomass were dominated by copepods, larvaceans, and meroplanktonic barnacle larvae (Fig. 3). Larger copepods, amphipods, and euphausiids were not abundant.

In 2009, an average abundance of 6400 individuals m^{-3} (14.3 mg DW m^{-3}) of holoplankton and 625 individuals m^{-3} (6.0 mg DW m^{-3}) of meroplankton were captured by the 150-µm nets. An average of 190 individuals m^{-3} (7.0 mg DW m^{-3}) of holozooplankton was captured by the 505-µm nets. For both sizes of nets, abundance was again dominated by copepods, larvaceans, and meroplanktonic barnacle larvae, but also including large numbers of pteropods. In contrast, biomass had little contribution from larvaceans, whereas meroplankton as well as chaetognaths became more important. Larger copepods, amphipods and euphausiids were more abundant than in 2008.

Multidimensional scaling of the zooplankton communities using Bray-Curtis similarity (Fig. 4) suggests some temporal progression of the communities. For example, the cold water at Burger on the first 2008 cruise places stations at one end of the trajectory while the warmest waters observed at Klondike on the third 2008 cruise places stations at the other end. There was almost no overlap in community structure between the 2 years for either size of net.

Perspective

The inter-annual variability of the planktonic communities for the northeastern Chukchi Sea in 2008/2009 appears to be related to the timing of the ice retreat. The late ice retreat observed during the 2008 season prevented warming of the water column. Low temperatures impede zooplankton growth and development, thus decreasing the abundance of food available for higher planktonic trophic levels. In the 2009 season, sea ice retreat was much earlier in the season, the water column was warmer, the zooplankton communities grew faster, and ultimately attained higher biomass, thereby increasing food available for higher trophic levels that feed in the planktonic realm.

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